

Section 3 Recycled Uranium

DOE/RL-2000-43

3.0 Recycled Uranium

3.1 Uranium Recycle Description

This chapter is designed to quantitatively define the recycled uranium flows to and from Hanford. The transactions into and out of Hanford will focus on the 300 Area Fuel Fabrication complex of facilities and the UO₃ Plant (224-U Building).

3.1.1 Hanford Key Interfaces for Recycled Uranium

For the Uranium Recycle Project, the Hanford Site is designated as a "Source Site". A source site is viewed as one at which uranium fuel is irradiated, chemically separated, and shipped to offsite locations. These offsite locations are referred to as "Tier 1" sites. Tier 1 sites are those which received recycled uranium directly from the Hanford Site. From the Hanford perspective, uranium transactions offsite are divided into "Major Tier 1" sites and "Minor Tier 1" sites. The distinction is made primarily as it relates to the quantities of recycled uranium shipped and/or received. The Major Tier 1 and Minor Tier 1 sites (from Hanford's perspective) are identified below:

Major Tier 1 Sites:

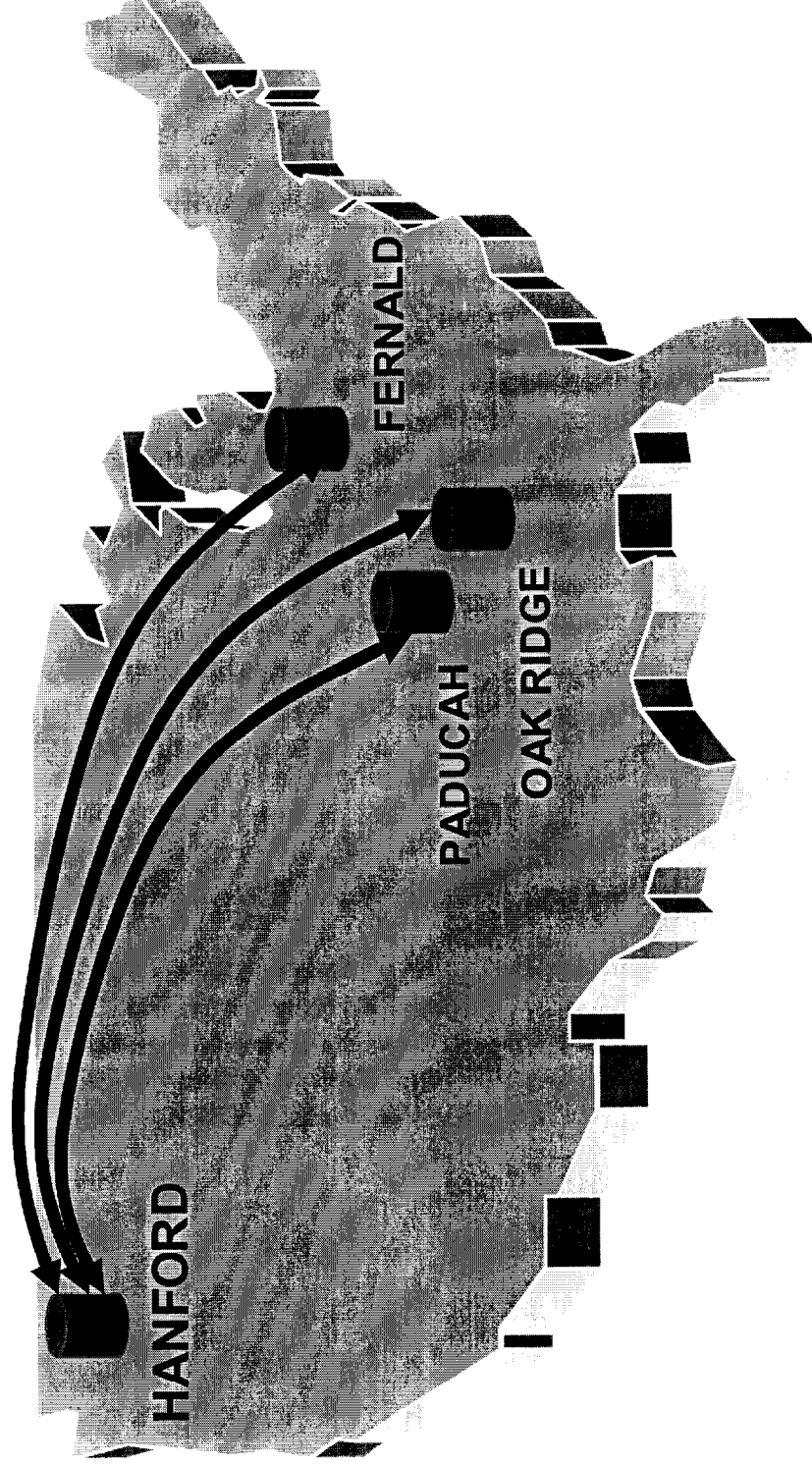
- Paducah Gaseous Diffusion Plant (GDP), Kentucky
- Fernald, Ohio (FMPC), previously National Lead of Ohio (NLO)
- K-25 Gaseous Diffusion Plant & Y-12 Plant, Oak Ridge, Tennessee

Minor Tier 1 Sites:

- All others (see Appendix B tables for these sites)

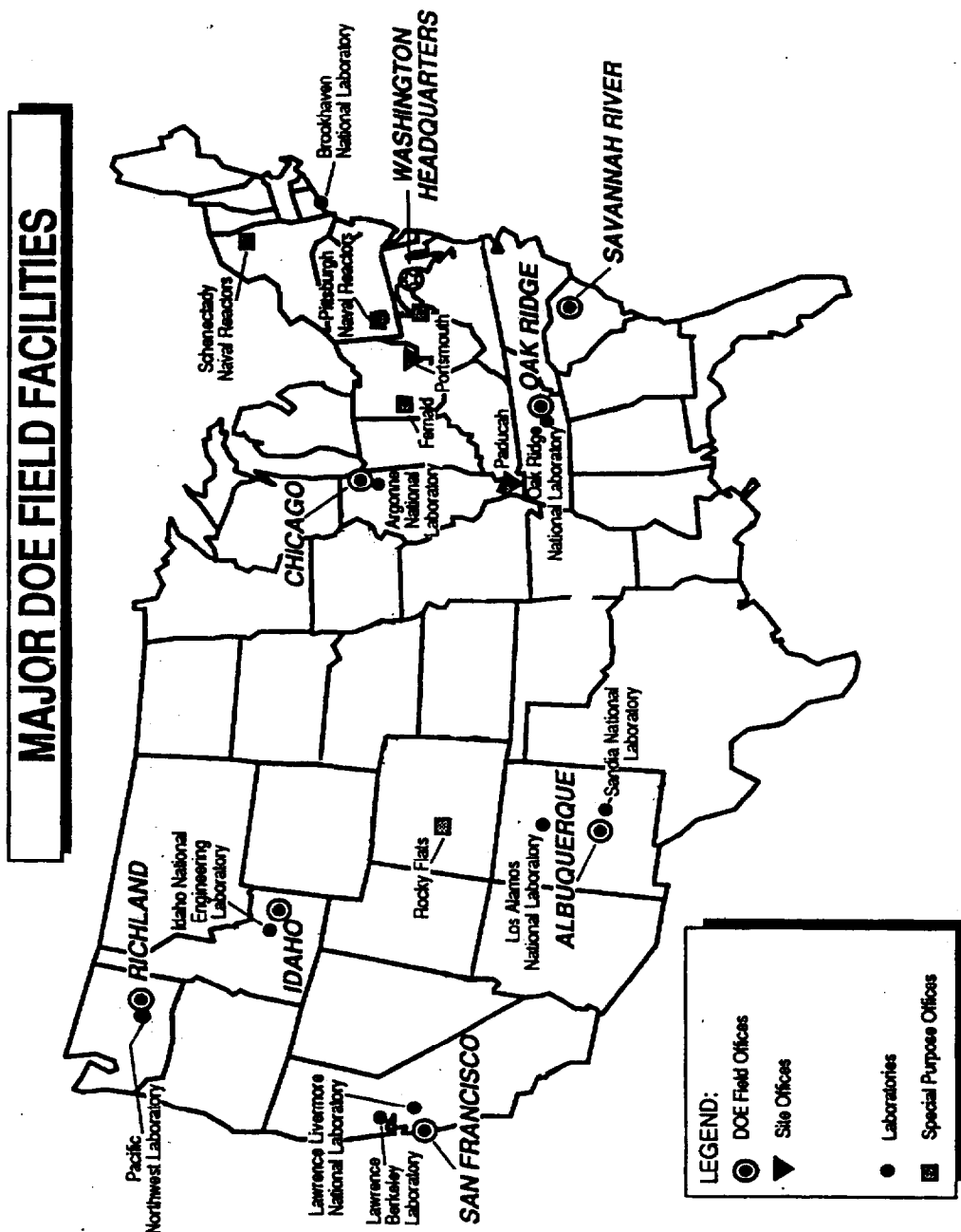
Major Tier 1 site locations are shown in Figure 3-1. Figure 3-2 shows the locations of many of both the Major and some of the Minor Tier 1 site locations. Figures 3-3A through Figure 3-3D show the flow of material through the complex for various time periods [DOE/EM-0319 1997]. There have been no reviewed records which indicate transfers of recycled uranium directly to the Portsmouth GDP.

Figure 3-1 Major "Tier 1" Sites for Hanford Recycled Uranium Transactions



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III

Figure 3-2 Major DOE Field Facilities

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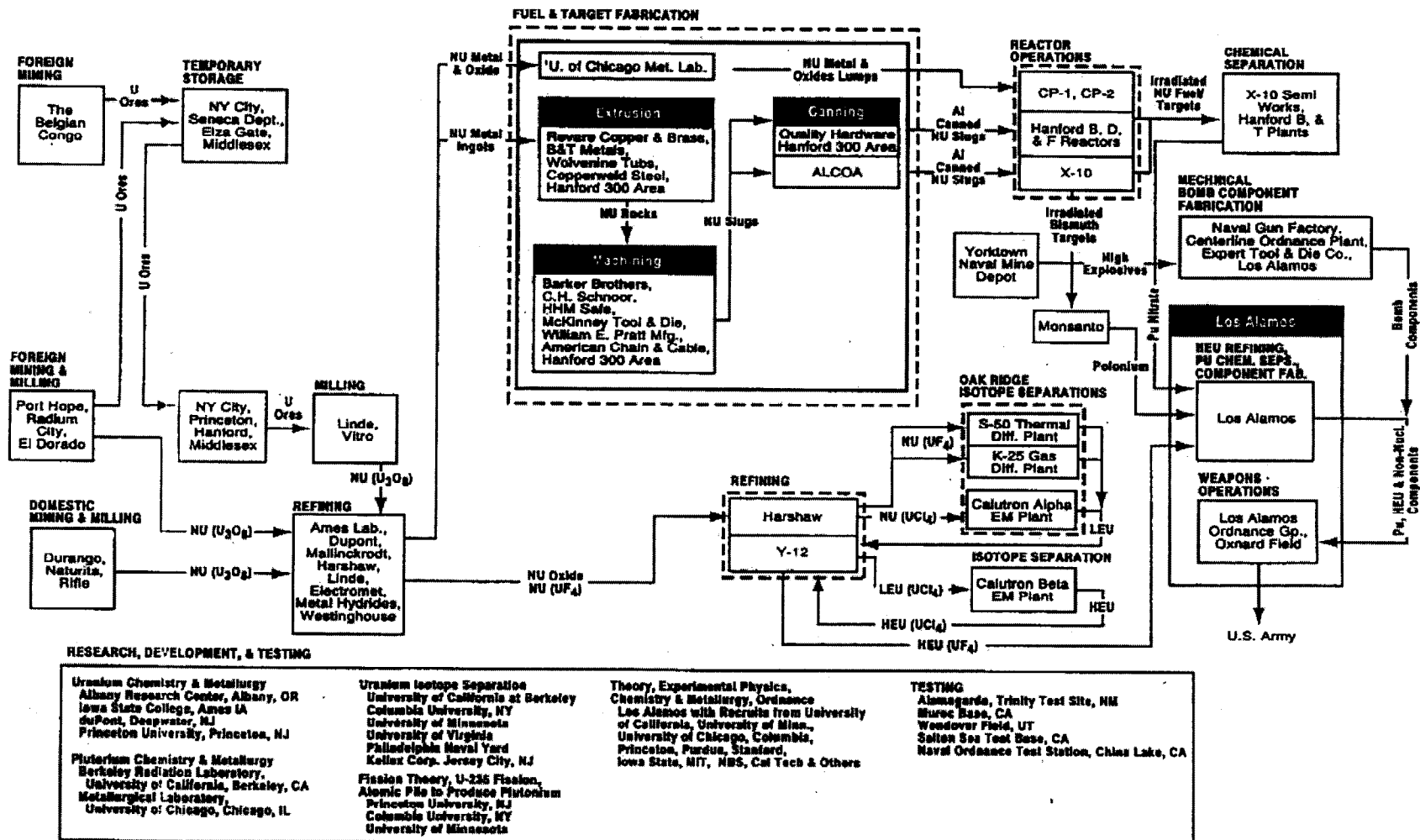


Figure 3-3A Material Flow – Manhattan Engineer District: 1942 – 1946 [DOE/EM-0319 1997]

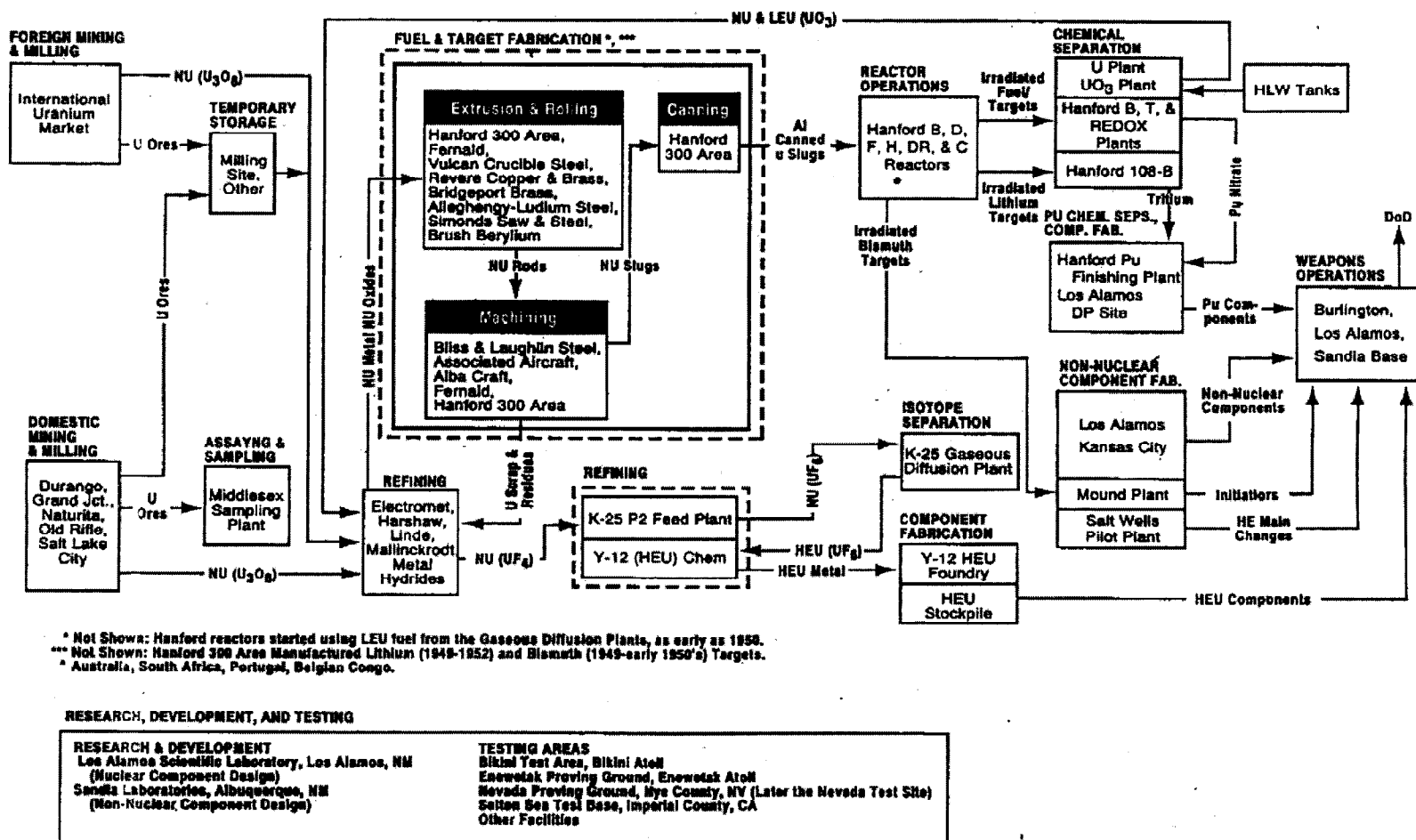


Figure 3-3B Material Flow – Atomic Energy Commission: 1946 – mid 1950s [DOE/EM-0319 1997]

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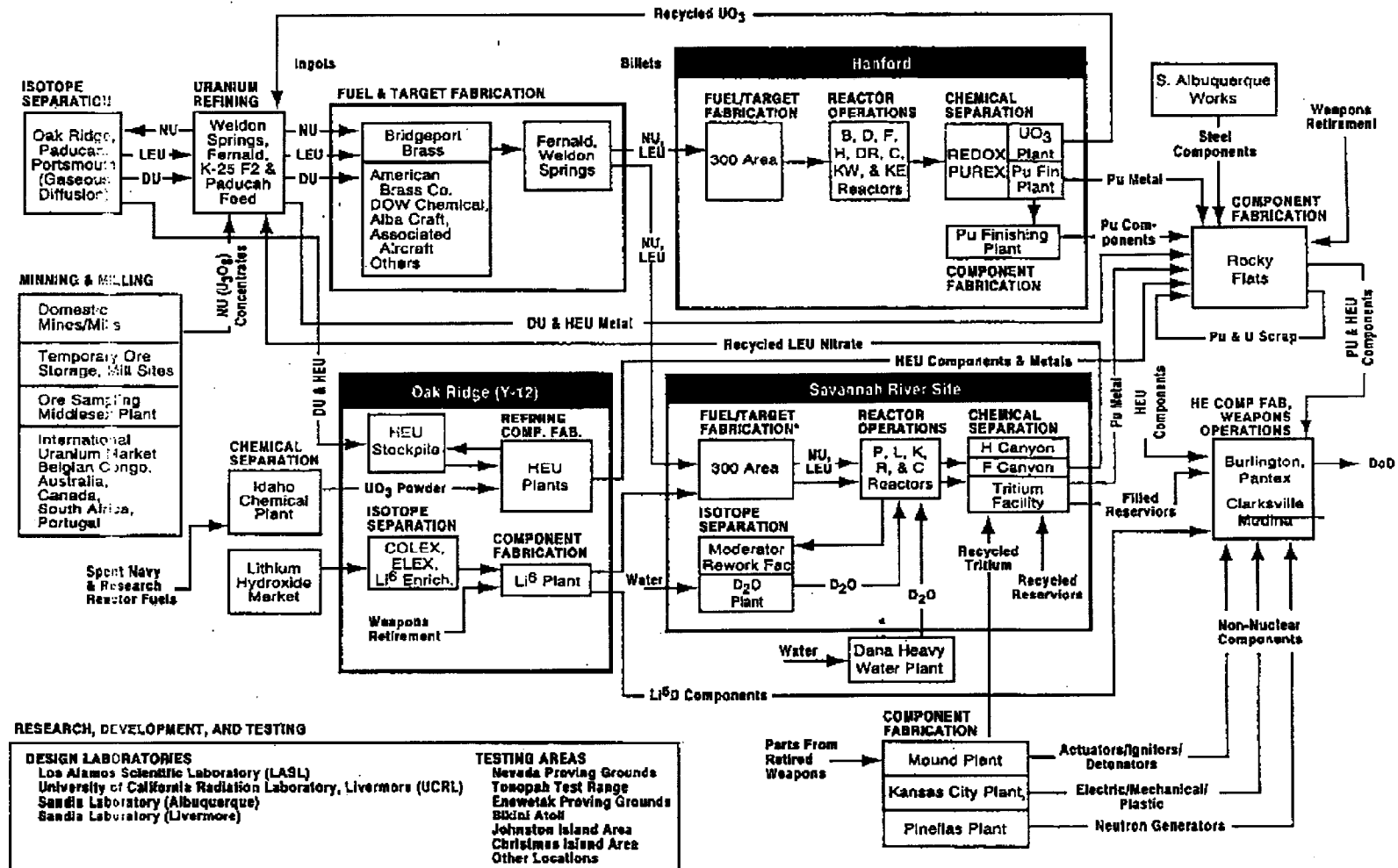


Figure 3-3C Material Flow – Atomic Energy Commission: mid 1950s – mid 1960s [DOE/EM-0319 1997]

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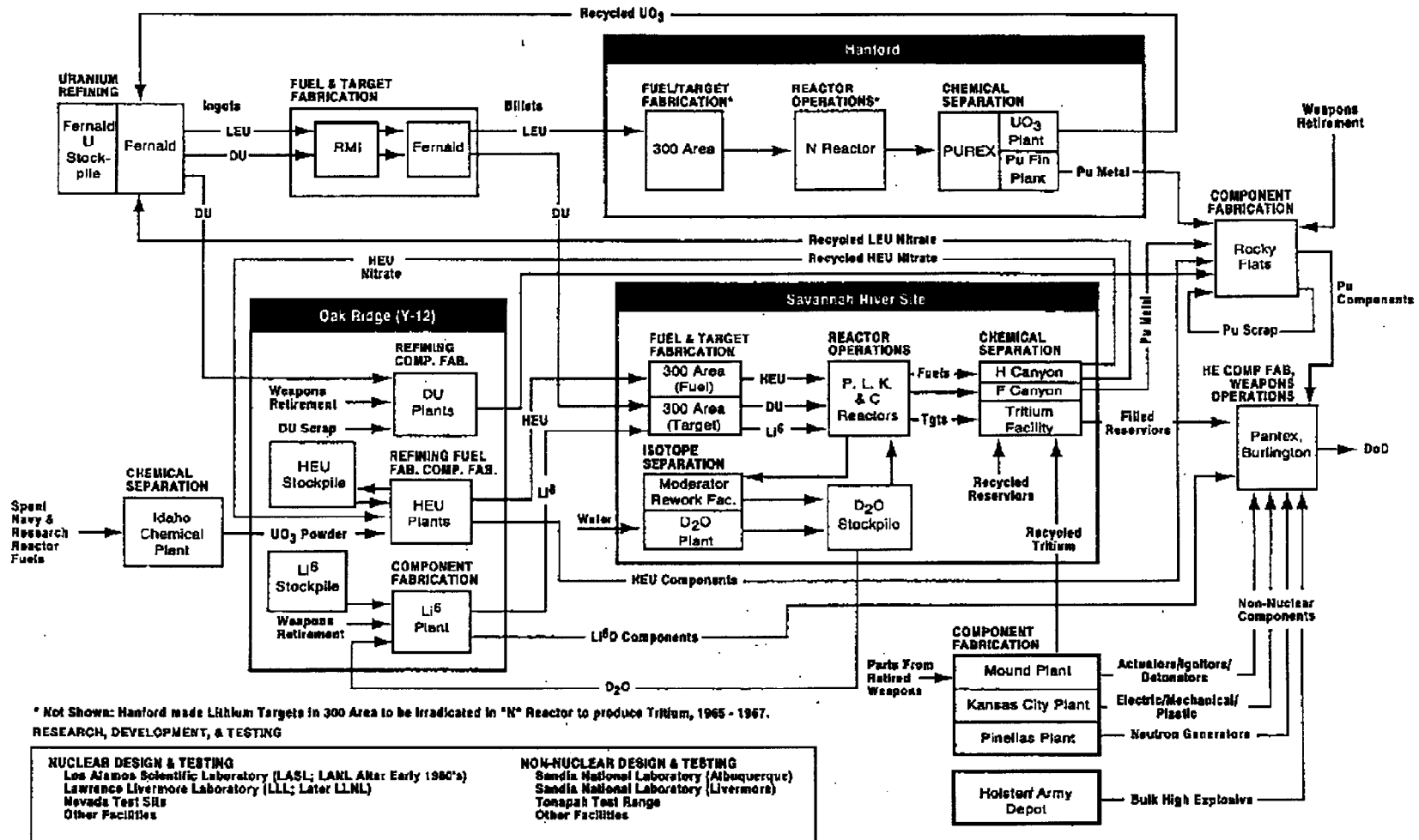


Figure 3-3D Material Flow – Atomic Energy Commission/Energy Research and Development Agency/Department of Energy: mid 1960s – late 1980s [DOE/EM-0319 1997]

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3.1.2 Beginning of Hanford In-Scope Recycled Uranium Transactions

3.1.2.1 Key Hanford Historical Dates for Recycled Uranium

Beginning of Recycled Uranium Shipments **OUT** of Hanford:

Depleted Uranium:	Mar 1952	UO ₃ product to Oak Ridge K-25
Normal Uranium:	July 1952	Metal scrap returns to offsite fuel reprocessors
Enriched Uranium:	July 1952	Research & development quantities
Enriched Uranium:	Mar 1959	UO ₃ LEU product to Oak Ridge K-25 (Production Channel)

Beginning of Recycled Uranium Receipts **INTO** Hanford:

Depleted Uranium:	July 1952	Hanford UO ₃ heels in returned drums from Oak Ridge K-25
Normal Uranium:	July 1952	Metal billets from offsite fuel fabricators
Enriched Uranium:	July 1952	Research and development quantities
Enriched Uranium:	July 1960	Metal LEU billets from Fernald (Production Channel), at parts per trillion Pu (from cascades)
Enriched Uranium:	Oct 1963	Metal LEU billets from Fernald (Production Channel) (at parts per billion Pu)

3.1.2.2 Production Channel Material Transactions

3.1.2.2.1 Shipments

For UO₃ finished product from the Hanford production channel, the first lot of UO₃ was rail shipped to K-25 on January 25, 1952 and consisted of 8 drums of Lot 001 [Richards 1952b]. The second shipment (Lot 002, 7 drums) was shipped to K-25 on February 11, 1952 [Richards 1952]. Both of these lots were produced from natural uranium and contained no fission products. They were "cold" test runs to validate the UO₃ conversion process. This material was shipped to K-25 to make sure the physical (particle size) and metallic impurities were within Oak Ridge acceptance criteria. As the "cold" UO₃ was examined and found acceptable, Hanford began spiking the feed stream with UNH from irradiated fuel.

Production records indicate shipment of recycled uranium trioxide product to the Oak Ridge K-25 GDP first occurred on March 10, 1952. Examples of the historical transfer documents, with attendant analytical data, are shown in Figures 3-4, 3-5, and 3-6. This March 1952 UO₃ shipment is consistent with Hanford production history indicating UO₃ test runs in January 1952 and full operation in February 1952.

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EW-23758

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March 11, 1952

Dr. Frank Hurd
Carbide and Carbon Chemicals Corporation
K-25 Plant
Oak Ridge, Tennessee

This Document consists of
2 Pages No. 6
19 Copies, Series

Dear Dr. Hurd:

Hanford
43666

UO₃ TRIAL PRODUCTION LOTS 007, 008, and 009

We are shipping by truck (United Motor Freight, GHL AT26971) Lots 007, 008, and 009 of UO₃ prepared from material processed through the Paducah plant. This shipment, consisting of 24 drums, left on March 10 and should arrive about March 17, directed to K-25 Plant, Oak Ridge, Tennessee, att'n F. E. Anderson - J. W. Aronoff. The average irradiation history of this uranium is considerably below the nominal 600 MR/t for full level material due to blending with cold uranium dissolver heels, etc. This is confirmed by the isotopic analyses reported in the table below. Results of other analyses on a composite sample of each lot are also given.

Classification cancelled (Change to

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by Authority of RLD-CG-5

Section 2.7.3.1

by CARBON

Verified By WHS Dr. Frank Hurd, K-25

3 AF Huber, K-25

4 WB Eames, K-25

5 Sylvan Greaser, K-25

6 Hanford Operations Office - Atomic Energy Commission -

Att'n: DG Sturges

8 AS Greminger - GH Greaser

9 JE Maider - TW Hanff

10 RS Bell - VR Chapman

11 VD Donihoe

12 JS

13 FW

14 RH

15 FW Albaugh - AH Eashey

16 300 File

17 700 File

18 Pink

19 Yellow

Very truly yours,

R.B. Richards

R. B. Richards, Manager
Separations Technology Unit

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CW 3-23-95

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Figure 3-4A First Hanford Shipment of UO₃
Containing Transuranics & Analytical Data
[Richard 1952a]

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nu-a-107
HAN-43666

Dr. Frank Eard

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March 11, 1952

Component or Property	Reported as	Lot 007	Lot 008	Lot 009
UO ₃	%	97.9	97.7	97.4
H ₂ O	"	0.21	0.23	0.26
NO ₃	2HNO ₃	0.05	0.61	0.55
U ₃ O ₈	%	0.12	0.1	0.11
Na	ppm	3000	3000	2500
PO ₄	"	1500	1500	1500
Fe	"	700	950	550
Mn	"	20	20	20
Mo	"	50	50	< 50
Cr	"	2	2	5
W	"	< 100	< 100	< 100
Si	"	10	10	50
B	"	< 0.2	< 0.2	< 0.2
S	"	27	6	< 1
Al	"	5000	5000	5000
Particle Size	% thru 80 Mesh	98.2	99.0	97.7
Bulk Density	g./cc.	1.99	2.07	1.75
Surface Area	sq. m./g.	1.3	1.035	1.2
Pu	ppb	< 5	< 5	< 5
f.p. activity, %	"	< 5%	< 5%	< 10%
f.p. activity, %	"	< 70%	< 100%	< 56%
U ₂₃₅	% of U	0.68	0.68	0.67

* %, relative to (beta or gamma) activity of an equal weight of natural uranium

Figure 3-4A (Continued) First Hanford Shipment Containing
Transuranics and Analytical Data
[Richards 1952a]

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EM-23846

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March 19, 1952

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Copies, Series

Dr. Frank Hurd
Carbide and Carbon Chemicals Corporation
K-25 Plant
Oak Ridge, Tennessee

Dear Dr. Hurd:

UO₃ TRIAL PRODUCTION LOTS 010, 011, 012, and 013

We are shipping by rail (car Milwaukee 1014, CHL AT-26979) lots 010, 011, 012, and 013 of UO₃ prepared from nominal 600 MWD/t material processed through the Redox Plant. This shipment, consisting of 32 drums and 4 boxes, left on March 19 and should arrive on March 24, directed to K-25 Plant, Oak Ridge, att'n F. H. Anderson - J. W. Arendt. Results of analyses of a composite sample of each lot are given below.

Classification cancelled (Change to

UNCLASSIFIED)

By Authority of RLO-CG-5

Section 1.4.3

By CA Bayman-PN2

Verified By WAC-co 11/14/94
RBL:JEM:blp

Yours very truly,

R. B. Richards, Manager
Separations Technology Unit
Technical Section, Engineering Dept.

By J. B. Work
J. B. Work

bcc: 1-2 Dr. Frank Hurd, K-25
3 AP Huber, K-25
4 MS Himes, K-25
5 Sylvan Cromer, K-25
6-7 Hanford Operations Office - Atomic Energy
Commission - Att'n: EC Stanges
8 AB Greeninger - OH Greager
9 JE Meider - TW Ruff
10 RS Bell - VR Chapman
11 VD Donibee
12 JB Work - RB Richards
13 FW Woodfield
14
15
16
17
18 Pink
19 Yellow

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Date 11/14/94
U.S. Department of Classification

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MATERIALS *Unrec'd*

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Figure 3-4B Second Hanford Shipment Containing Transuranics and Analytical Data
[Work 1952]

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HA-23848

Dr. Frank Hurd

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March 19, 1952

Component or Property	Reported as	Lot 010	Lot 011	Lot 012	Lot 013
UO ₃	%	97.3	97.6	98.0	98.1
H ₂ O	"	0.27	0.24	0.24	0.23
NO ₃	Σ NO ₃	0.65	0.55	0.62	0.54
U ₃ O ₈	%	0.24	0.46	0.35	0.45
Na	ppm	2500	2500	5000	2000
PO ₄	"	< 15	< 15	< 15	150
Fe	"	174	177	133	116
Ni	"	< 10	< 10	< 10	< 10
Mo	"	< 50	< 50	< 50	< 2
Cr	"	1	10	1	< 1
W	"	< 10	< 10	< 10	< 10
Si	"	10	20	50	25
B	"	< 0.2	< 0.2	< 0.2	< 0.2
S	"	7	< 1	< 1	< 1
Al	"	2500	2000	2000	1500
Particle Size	% thru 80 Mesh	95.5	96.4	99.1	88.7
Bulk Density	g./cc.	2.2.	1.69	1.75	2.10
Surface Area	sq. m./g.	1.1	1.15	1.0	1.0
Pu	ppb	< 5	< 1	< 5	< 1
f.p. activity, β	*	< 5%	29%	18%	18%
f.p. activity, δ	*	83%	105%	82%	77%
U ₂₃₅	% of U	0.67	0.66	0.66	0.66

* %, relative to (beta or gamma) activity of an equal weight of natural uranium

Figure 3-4B (continued)
Second Hanford Shipment of UO₃ - Analytical Results
[Work 1952]

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<p>ROUTE TO:</p> <p>JG Murphy</p>		<p>FILES ROUTE</p> <p>271-U Bldg. MAR 10 1971</p>	
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Figure 3-5 Example of Historical Transfer Forms-Cover Page

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Page 1 of 2

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[illegible]

18 U.S.C., SECTION 1001; ACT OF JUNE 25, 1948, 62 STAT. 749; MAKES IT A CRIMINAL OFFENSE TO MAKE A WILLFULLY FALSE STATEMENT OR REPRESENTATION TO ANY DEPARTMENT OR AGENCY OF THE UNITED STATES AS TO ANY MATTER WITHIN ITS JURISDICTION.

GPC 357.014

6-11-71

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208

(CLASSIFICATION)

UO ₃ — PRODUCT ACCEPTANCE			
LOT NUMBER 1-5-2 & 1-5-3			
TRANSFER SERIES HVA-FYA-133	GROSS WEIGHT	Lot-1-5-2 28 210 Lot-1-5-3 56 234	Lbs.
SHIPPED TO Union Carbide Corporation	TARE WEIGHT	7 570	Lbs.
GBL NUMBER E-8607-725	NET WEIGHT	24 390 48 664	Lbs.
MATERIAL Depleted UO ₃	DATE SHIPPED	6-1-71	
NO. OF CONTAINERS Lot-1-5-2 2 cont. Lot-1-5-3 4 cont.	NET SAMPLE WEIGHT	Lot-1-5-2 3 Kgs. Shipped 5-28-71 82.04	
CAR NUMBER UP-508825	AVERAGE PERCENT U	81.90	
SEAL NUMBERS HGE-6803 & 6804	AVERAGE PERCENT U-235	0.658 Est.	
SUBMITTED BY: <u>G.B. Kuklinski</u> ATLANTIC RICHFIELD HANFORD COMPANY			DATE 6-2-71
ACCEPTED BY: <u>A. M. Langston</u> U.S. ATOMIC ENERGY COMMISSION			DATE 6/7/71
<p>Shipment Pending on Lot-1-5-3</p> <div style="background-color: black; width: 300px; height: 40px; margin: 10px auto;"></div> <div style="background-color: black; width: 250px; height: 30px; margin: 10px auto;"></div> <div style="background-color: black; width: 150px; height: 20px; margin: 10px auto;"></div>			
<div style="background-color: black; width: 150px; height: 20px; margin: 0 auto;"></div> <p style="text-align: center;">CLASSIFICATION</p>		<p>THIS DOCUMENT CONSISTS OF 1 PAGES, NO. 1 OF 2 COPIES. SERIES</p>	
HANFORD CATEGORY C-65			

Figure 3-6 Example of Historical Product Acceptance Form
Hanford Depleted UO₃ to Paducah (circa 1971)

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In March 1959, General Electric was authorized by the AEC to begin routine shipments of low-enriched (0.94% ^{235}U before irradiation) UO_3 to the K-25 facilities in Oak Ridge [Gifford 1959]. Hanford LEU UO_3 shipments began soon thereafter. From this March approval-to-ship to the end of June 1959, Hanford produced and shipped approximately 288 MTU of the low-enriched (0.85%) UO_3 to Oak Ridge. Although the K-25 facility was the first recipient of Hanford recycled uranium, the vast majority of the UO_3 product was shipped to the Paducah site beginning in FY 1954 through FY 1972.

The third major recipient of Hanford recycled UO_3 was the Fernald site, which began receiving research quantities of depleted UO_3 in FY 1953. Although Fernald received small quantities of Hanford depleted UO_3 , they were the major recipient of Hanford low-enriched recycled UO_3 beginning in the early 1960s through March 1989. These shipments originated from the Hanford chemical processing contractors (GE, Isochem, ARHO, RHO, WHC). Some small quantities of Hanford UO_3 which did not meet K-25 acceptance criteria for non-radioactive chemical purity were sent to Harshaw for purification. The majority of Hanford UO_3 shipped from Hanford to the K-25 plant was later shipped from K-25 to Paducah.

3.1.2.2 Receipts

Beginning in the late 1940s, Hanford received uranium product to support fuel fabrication activities. Metal feedstock was received from Mallinckrodt (St Louis and Weldon Spring, Missouri), and Simonds. Fuel samples were exchanged with many sites as this new technology was rapidly growing. With the Fernald Plant coming on line in March 1953, an increasing quantity of uranium was received and shipped between Hanford and Fernald. Hanford receipt of recycled uranium is assumed to begin in July 1952 (FY 1953) as material shipped from Hanford offsite between March through June 1952 could not have reasonably been received, reprocessed, and returned as feedstock from offsite until that time. In discussions with Fernald staff, normal (recycled) uranium metal feedstock initially received at Hanford could be expected to have contained only parts-per-trillion quantities of plutonium. Further discussions concerning the Hanford receipts are detailed in Section 3.2. Figure 3-7 (based on a 1949 document) shows the flow of uranium received into Hanford's 300 Area Fuel Fabrication facilities.

3.1.3 Out-of-Scope Uranium Transactions

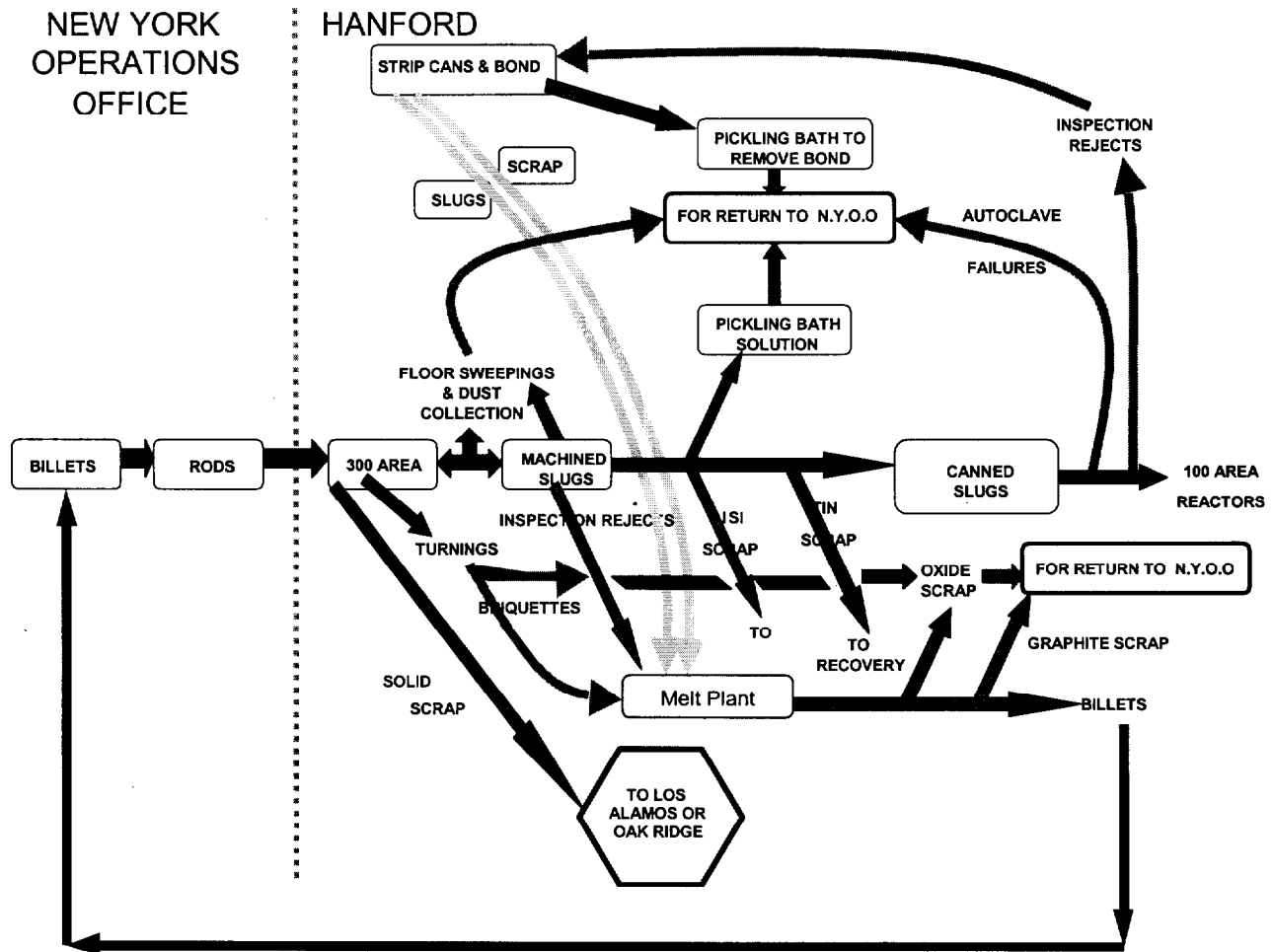
3.1.3.1 Hanford Production Channel

Prior to March 1952, uranium shipments were confined to natural uranium scrap from Hanford's 300 Area Fuel Fabrication activities or metallurgical and process research involving UNH solutions. Natural uranium metal rods were received, principally from the New York Operations Office contractors, and processed at the 300 Area. The unirradiated scrap generated, in various forms, was sent offsite for reclamation. The finished fuel, termed "slugs" were "canned" and sent to the Hanford reactors for subsequent irradiation. Significant effort was made at Hanford in the early 1950s to reclaim and reuse as much of the generated uranium scrap due to the shortage of

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feedstock within the production complex. The fuel fabrication process had no input points at which transuranics could be introduced into the unirradiated fuel manufacturing process. There has been no evidence of any transuranic contaminants being introduced into the fuel within the Hanford manufacturing process.



**Figure 3-7 1949 Schematic Diagram Showing Uranium Flow in 300 Area
(based on HAN-25257, dated May 25, 1949)**

3.1.3.2 Out-of-Scope Research and Development Programs

As the development for increased uranium fuel productivity and chemical integrity continued during the late 1940s and early 1950s, small amounts of uranium were diverted from the production channels for research and development. The three areas of R&D were 1) Exponential Pile Program; 2) Fuel Development Metallurgy; and 3) Separations Technology. One such research program, referred to as the Pile Enrichment program, involved transfers of unirradiated slugs between the Y-12 Plant

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and Hanford. Hanford received the bare slugs from the Y-12 Plant, canned them, and returned slugs, scrap metal, and reject slugs to Y-12. There is no indication that these slugs contained recycled uranium, and are therefore considered out-of-scope transactions.

A subsequent part of the R&D program sent irradiated slugs to the Idaho Chemical Processing Plant (ICPP). These J-1 slugs were also irradiated at H reactor and the J-2 slugs at C reactor. The "C" slugs were irradiated at C and H reactor. As the ICPP came on line, shipments of these "J" irradiated slugs began in late calendar year 1951 and were reported in a 1952 Material Balance Report, FTS-953 [Donihee 1952]. As spent fuel, the irradiated slugs sent to Idaho are considered out-of-scope for this project.

Another mid-1960 AEC research program, termed the Plutonium Credit Activity, involved shipment of Hanford irradiated fuel to Nuclear Fuel Services (NFS) in West Valley, New York [DOE 1999]. Uranium contained in this spent fuel is also considered out-of-scope for this study.

3.1.3.3 Recycled Uranium Timeframe Summary

Summaries of recycled uranium transfers at Hanford have been separated into two distinct timeframes. The period from January 1952 through June 1970 (FY 1970) represents the initiation of Hanford processing of recycled uranium from one or more separation plants. (In 1967, REDOX (S-Plant) shut down.) The second period from July 1970 through the present (March 1999) represents a period in which the PUREX plant (when operating) was the sole separation plant for Hanford's Defense missions. This later period is also one in which Hanford supported multiple non-defense missions, such as the Fast Flux Test Facility, under multiple Hanford contractors.

Quantities of uranium shipped and received are presented in Sections 3.2 and 3.3 and further detailed in Appendix B.

3.1.4 Data Presentation – Isolation of Specific Timeframes

This narrative section is prepared to explain the Hanford Recycled Uranium Project team's approach to quantitatively define recycled uranium materials that were shipped into and out of the Hanford Site since its inception in 1943 until March 30, 1999. To simplify reporting, Hanford shipments and receipts include the aggregate of the fuel fabrication/reactor operations contractors (Douglas United, UNI) and the chemical processing contractors (Isochem, ARHO, Rockwell, Westinghouse, Fluor) after contractor turnover from General Electric (GE, 1965-66 turnover). The Pacific Northwest National Laboratory (PNNL) and its predecessors offsite shipments and receipts are addressed separately.

In an effort to simplify the data investigation, the team chose to separate the Hanford Site uranium transactions to correspond to the following four timeframes:

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- Late 1940s – December 31, 1951: Hanford Site external shipments and receipts from December 1947-December 31, 1951 encompasses the General Electric Company (GE), which solely operated the fuel fabrication, reactors, and chemical separations plants. This first timeframe was isolated to define a demarcation between In-Scope and Out-of-Scope uranium transactions. All transactions within this timeframe have been evaluated as Out-of-Scope to this project. These transactions, detailed in Section 3.2 and 3.3, were almost exclusively natural uranium product and scrap transfers between the New York Operations Office (NYOO) and its contractors and Hanford's Fuel Fabrication facilities.
- January 1, 1952 – June 30, 1965: This timeframe represents the beginnings of Hanford transactions involving recycled uranium under a single GE Company contractor. This period also represents a high production timeframe. As the research for safer and more efficient plutonium production continued, more offsite facilities become recipients and suppliers for recycled uranium into and out of Hanford. In the early 1950s, the major NYOO contractors were replaced primarily by the Fernald and Weldon Spring (Mallinckrodt) facilities as the major suppliers of Hanford metal feedstock and recyclers of Hanford scrap.
- July 1, 1965 – June 30, 1970: This timeframe represents a transitional period of Hanford contractor turnover from the GE Company to multiple contractors and the beginnings of implementation of a DOE-wide Nuclear Materials Management and Safeguards System (NMMSS). PNL, assumed the management of Hanford Laboratories in 1965 as an independent research entity from Hanford Operations.
- July 1, 1970 – March 30, 1999: This timeframe includes the period when the PUREX Plant became the sole producer of UNH for Hanford. The NMMSS MC&A system became operational (complex-wide). Recycled uranium transactions between Hanford and Paducah and Oak Ridge were minimal, and the vast majority of transactions for Hanford were with Fernald (NLO, FMPC, FEMP) and Reactive Metals Incorporated (RMI, Ashtabula Extrusion Plant).

3.1.5 Hanford Historical Timeline References

In tracing the historical transfers, the key activities and timeframes listed below were identified as potentially significant for the purposes of this study. (A more complete Hanford historical timeline of events is provided in Appendix H.)

- Events Related to Hanford:

1950:	Paducah Gaseous Diffusion Plant sited
1951:	Savannah River Plant sited
1951:	Fernald Feed Materials Production Plant (Ohio) sited
1952:	Fernald production begins
1953:	Paducah GDP becomes operational

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- Hanford Contractor timeline:

December 21, 1942:	Du Pont signed to construct/operate atomic plants
September 1, 1946:	General Electric Company (GE) assumes control as overall Site Contractor
1965 to 1966:	GE replaced by multiple contractors
September 1965 - 1973	<u>Fuel Fabrication & Reactor Operation:</u> Douglas United Nuclear (DUN-joint venture subsidiary of Douglas Aircraft Co. and United Nuclear Corp.)
1973-1979	United Nuclear Industries
1979-1987	United Nuclear Corporation (UNC)
1987-1996	Westinghouse Hanford Operations (WHC)
October 1996 - Current	Fluor Hanford Incorporated (FHI)
January 1966 - September 1967	<u>Chemical Separations, Processing & Production</u> Isochem (joint venture subsidiary of U.S. Rubber Co. and Martin Marietta Corp.)
September 1967 - October 1967	Atlantic Richfield Hanford Company, chemical processing operations
October 1977- July 1987	Rockwell Hanford Company, chemical processing operations
July 1977 - October 1996	Westinghouse Hanford Operations, reactor operations and chemical processing
October 1996 - Current	Fluor Hanford Incorporated (FHI)
January 1965 - 1977	<u>Research & Environmental Monitoring</u> Battelle Memorial Institute (BNWL) (became PNL)
1977 – Current	Pacific Northwest Laboratory (PNL)(became PNNL)

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- Government Agencies Having Control of Hanford Site:

1943 - 1946	U. S. Army, Manhattan Engineer District
1947 – 1974	Atomic Energy Commission (AEC)
1/1/75 – 9/30/77	Energy Research and Development Administration (ERDA)
10/1/77 – Current	U. S. Department of Energy (DOE)

3.1.6 Key Dates/Assumptions for Uranium Transactions

May 5, 1950:	First shipment of unirradiated EU “J” slugs to Y-12
January 1952:	First recorded shipments of irradiated EU slugs to Idaho ICPP
January 1952:	Depleted UO_3 product was shipped (no fission products)
March 10, 1952:	First recorded shipment of UO_3 product to K-25 GDP with fission products
July 1952:	First assumed return of recycled uranium into Hanford
July 1958	Scheduled start of enriched UNH input into UO_3 Plant [Gustafson 1957]

March-June, 1959: First production and shipment of enriched UO_3 to K-25

3.1.6.1 Beginning Shipment of Recycled Depleted Uranium Trioxide (UO_3)

As previously noted, the first shipment of recycled UO_3 produced at Hanford was shipped to Oak Ridge, Tennessee on March 10, 1952. Trial Production Lots 007, 008, and 009 were prepared from nominal 600 MWD/t material processed through the REDOX Plant. This initial truck shipment consisted of 24 drums and was sent to the K-25 Plant. The analytical results of composite samples for each lot were also provided [Richards 1952] and are shown in Figure 3-4. Further discussion of Hanford analytical data and product quality is detailed in Section 4.0.

3.1.6.2 Initial Shipments of Recycled Low-Enriched Uranium Trioxide (UO_3)

The first shipments of low-enriched (0.8 -0.9% ^{235}U) UO_3 to Oak Ridge were approved by the AEC on March 3, 1959. Shipments were initially to be made to the K-25 Facility [Gifford 1959].

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3.2 Recycle Uranium Receipts

3.2.1 Uranium Forms Received from Offsite

The principal uranium form received at Hanford since its inception until the end of fiscal year 1988 was metal as either rods or billets to support fuel fabrication for Hanford Defense reactors. Figure 3-8 shows a typical box of inbound metal billets.

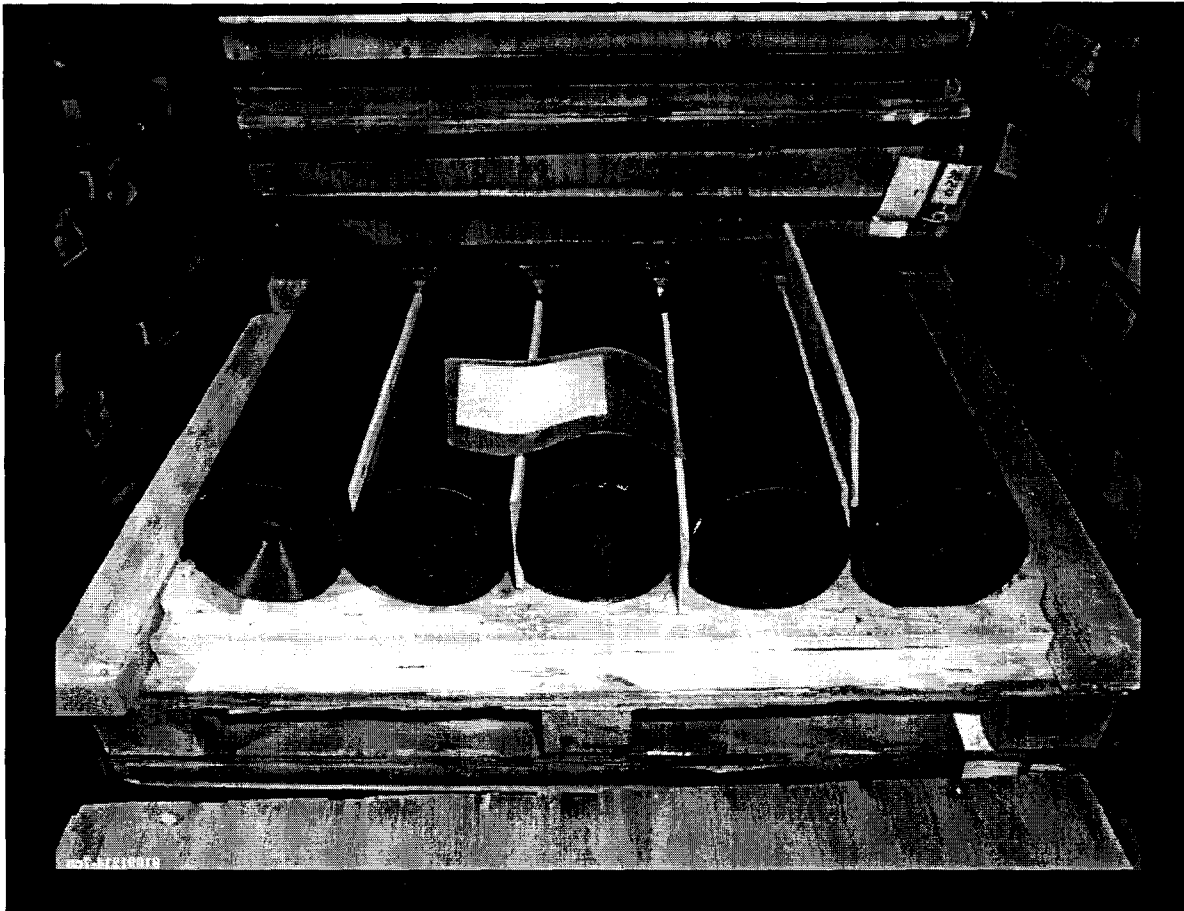


Figure 3-8 Typical Metal Billet Receipt Inbound from RMI/Fernald in the 1980s

To add some perspective, billets were typically 6-18 inches in diameter and ranged from 110 to as much as 190 Kg each. On a much smaller scale, as the UO_3 shipping containers were cycled back to Hanford from the Major Tier 1 sites, relatively small amounts of UO_3 were received as heels remaining in the returned shipping containers.

3.2.2 Initial Recycled Uranium Receipts into Hanford

- Depleted Uranium: July 1952 Hanford UO_3 heels in returned drums from Oak Ridge K-25
- Normal Uranium: July 1952 metal billets from offsite fuel fabricators

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- Enriched Uranium: July 1952 research and development quantities
- Enriched Uranium: July 1960 metal LEU billets from Fernald from production channel (Pu in parts per trillion U) (from cascades)
- Enriched Uranium: October 1963 metal LEU billets from Fernald (Pu in parts per billion U)

3.2.3 Receipts Prior to July 1952 (Out-of-Scope)

In the late 1940s, Hanford receipts were natural uranium billets and rods from various metal fabricators under the management of the New York Operations Office (NYOO). Many of these same contractors were the recipients of Hanford shipments of scrap generated during the fuel fabrication activities and are detailed in Section 3.3. In the late 1940s and early 1950s, a majority of the Hanford billets were supplied by Mallinckrodt Chemical Works (MCW) and originated from three types of MCW cast ingots which included 1) ingots cast from natural uranium derbies; and 2) ingots recast from ingot croppings; and 3) ingots recast from reject slugs, rod ends, and rolling mill scrap [Greninger 1953]. Any uranium received at Hanford before July 1952 would not have contained reactor-produced fission products or radionuclides. There would have been no ^{236}U in these uranium receipts but would have contained the same distribution of uranium isotopes as present in natural or enriched uranium from a GDP cascade.

3.2.4 Beginning Receipts of Recycled Uranium at Hanford

The beginning receipts of metal feed stock with trace transuranics into the 300 Area is assumed to begin in July 1952 (FY 1953). This assumption is based on the logic that transuranics in the March 1952 UO_3 shipped offsite, could not have reasonably been processed and re-introduced into the returning metal billets until July 1952. Throughout the 1950s, Hanford continued to receive substantial metal feedstock from the NYOO contractors (Mallinckrodt Chemical Works, Simonds Saw & Steel, etc.). The largest shipper of metal feedstock during the mid-1950s and until the 1980s was the National Lead of Ohio Company (NLO) plant in Fernald, Ohio. NLO was renamed the Feed Materials Production Center (FMPC) in the 1950s. FMPC is now managed by the Westinghouse Materials Company of Ohio. FMPC is a Major Tier 1 site, being both the recipient of Hanford fuel fabrication scrap and UO_3 product and the supplier of metal billet feedstock. FMPC produced, via plants 6 and 9, normal and low-enriched ingots that were finished into billets at Reactive Metals Inc. (RMI) and shipped to Hanford's 300 Area. Informal discussions with Fernald staff, indicate that there were no input points at RMI that could introduce transuranic contaminants into the billets shipped to Hanford. RMI was essentially a heat treating and extruding facility.

3.2.5 Quantities of Recycled Uranium Received from July 1952-March 30, 1999

The summary of in-scope recycled uranium received at the Hanford contractor(s) starting in July 1952 until March 31, 1999 totaled approximately 109,200 metric tons. Of

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this total, approximately 85% was received from the three Major Tier 1 sites (~92,800 MTU). Yearly summaries for these three Major Tier 1 sites are detailed in Tables 3-1, 3-2, and 3-3. Summary fiscal year tables for all receipts by Hanford contractors are provided in Appendix B, Tables 3.2.1 through 3.2.8. These Appendix tables are divided into distinct timeframes to simplify transactions associated with the Hanford contractor turnover which occurred continually from 1965 onward. Summarized in Table 3-1 below is the total recycled uranium received from offsite sources at Hanford.

Table 3-1 Total Recycled Uranium Received from Offsite Sources

Timeframe:	MTUs Received: All Offsite Sources:	MTUs Rec'd Major Tier 1:	MTUs Rec'd Minor Tier 1:
FY 1953-FY 1965	77,603.7	72,869.5	4,734.2
FY 1966-FY 1970	19,119.5	19,109.6	9.9
FY 1971-3/31/99	12,420.4	788.0	11,632.4*
	109,143.6	92,767.1	16,376.5

*The majority of post FY 1971 receipts were from RMI Extrusion Plant (FTA) which supplied the Hanford fuel fabricator (United Nuclear, HXA).

3.2.6 Hanford Receipts of Recycled Uranium from Paducah

Hanford received residual UO_3 in returned containers from FY 1954 through FY 1964. The receipts from Paducah are detailed in Table 3-2.

3.2.7 Hanford Receipts of Recycled Uranium from Fernald and RMI (Ashtabula)

Hanford received metal billets from Fernald and Reactive Metals Incorporated (RMI), Ashtabula. Hanford also received residual UO_3 in returned shipping containers from Fernald. In 1983, incoming materials into the 300 Area were primarily 0.95% and 1.25% ^{235}U billets from RMI in Ashtabula, Ohio. The receiving rate was nominally 4 ½ loads per month at 18 metric tons uranium per load [Heaberlin 1983]. The receipts from Fernald are summarized in Table 3-3.

3.2.8 Hanford Receipts of Recycled Uranium from Oak Ridge

Hanford received relatively small quantities of UO_3 as heels in returned shipping containers and uranium metal for research programs. These receipts are summarized in Table 3-4.

3.3 Recycle Uranium Shipments

3.3.1 Recycled Uranium Streams Shipped Offsite:

Two major recycle uranium streams were shipped offsite from Hanford's beginnings until March 1999. The first of the two major streams was byproduct from the fuel

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Table 3-2 Hanford Receipts From Paducah

(IN MTU)			Union Carbide of Kentucky							
			Management by Oak Ridge Operations							
			CKY, FYA							
FY	Date		Into	Hanford	Box #	Doc #	DU	NU	EU	MTU
	From	To	RIS	Contractor						Total
1953	01-Jul-52	30-Jun-53	HGE	General Electric	38213	FTS 1085	0	0	0	0
1954	01-Jul-53	30-Jun-54	HGE	General Electric	38213	FTS 1311	0	0	0	0
1955	01-Jul-54	30-Jun-55	HGE	General Electric	38213	FTS 1481	0	0	0	0
1956	01-Jul-55	30-Jun-56	HGE	General Electric	38213	FTS 1644	0	0.002	0	0
1957	01-Jul-56	30-Jun-57	HGE	General Electric	38213	FTS 1980	2.2	0	0.7	2.9
1958	01-Jul-57	30-Jun-58	HGE	General Electric	38213	FTS CLVI 463-1A	2.2	0.049	0	2.2
1959	01-Jul-58	30-Jun-59	HGE	General Electric	38213	HAN 72720	2.9	0	1	3.9
1960	01-Jul-59	30-Jun-60	HGE	General Electric	38213	HAN 75996	1.9	0	0.1	2
1961	01-Jul-60	30-Jun-61	HGE	General Electric	38213	HAN 79125	2.9	0	0	2.9
1962	01-Jul-61	30-Jun-62	HGE	General Electric	38213	HAN 82406	3.4	0	0.6	4.1
1963	01-Jul-62	30-Jun-63	HGE	General Electric	38213	HAN 85615	4.1	0	0	4.1
1964	01-Jul-63	30-Jun-64	HGE	General Electric	38213	HAN 88957	2.4	0	0	2.4
1965	01-Jul-64	30-Jun-65	HZA	General Electric	38213	HAN 92119	0	0	0	0
FY 1952 - FY 1965 Subtotal							22	0.1	2.4	24.5
1966	1-Jul-65	30-Jun-66	HZA	General Electric	38213	HAN 95170				
1966	1-Jul-65	30-Jun-66	HWA	Isochem Inc.	38213	HAN 95136				
Hanford Chem Processing Contractor subtotals										
1966	1-Jul-65	30-Jun-66	HXA	Douglas United Nuc	38214	HAN 95171				
Hanford FY 66 Aggregate subtotal							0	0	0	0
1967	1-Jul-66	31-Dec-66	HZA	General Electric	39213	HAN 96413				
1967	01-Jan-67	30-Jun-67	HZA	General Electric	39213	HAN 98198				
1967	01-Jul-66	31-Dec-67	HWA	Isochem Inc.	38213	HAN 96400				
1967	01-Jan-67	30-Jun-67	HWA	Isochem Inc.	38213	HAN 98196				
Hanford Chem Processing Contractor subtotals										
1967	01-Jul-66	31-Dec-66	HXA	Douglas United Nuc	38214	DUN 1916				
1967	01-Jan-67	30-Jun-67	HXA	Douglas United Nuc	38214	HAN 98194				
Hanford FY 67 Aggregate subtotal							0	0	0	0
1968	01-Jul-67	31-Dec-67	HVA	Atlantic Richfield Han	46425	HAN 99439				
1968	01-Jan-68	30-Jun-68	HVA	Atlantic Richfield Han	46425	ARH 699				
Hanford Chem Processing Contractor subtotals										
1968	01-Jul-67	31-Dec-67	HXA	Douglas United Nuc	38214	DUN 3624				
1968	01-Jan-68	30-Jun-68	HXA	Douglas United Nuc	38214	DUN 4436				
Hanford FY 68 Aggregate subtotal							0	0	0	0
1969	1-Jul-68	31-Dec-68	HVA	Atlantic Richfield Han	46425	ARH 1036				
1969	1-Jan-69	30-Jun-69	HVA	Atlantic Richfield Han	46425	ARH 1099-6				
Hanford Chem Processing Contractor subtotals										
1969	1-Jul-68	31-Dec-68	HXA	Douglas United Nuc	38214	DUN 5250				
1969	1-Jan-69	30-Jun-69	HXA	Douglas United Nuc	38214	DUN 5942				
Hanford FY 69 Aggregate subtotal								0	0	0
1970	1-Jul-69	31-Dec-69	HVA	Atlantic Richfield Han	46425	ARH 1099-12				
1970	1-Jan-70	30-Jun-70	HVA	Atlantic Richfield Han	46425	ARH 1540-6				
Hanford Chem Processing Contractor subtotals								0	0	
1970	1-Jul-69	31-Dec-69	HXA	Douglas United Nuc	38214	DUN 6557				
1970	1-Jan-70	30-Jun-70	HXA	Douglas United Nuc	38214	DUN 7049				
Hanford FY 70 Aggregate subtotal							0	0	0	0
FY 1966 - FY 1970 Subtotal							0	0	0	0
1952-June 30, 1970 MTU Subtotal							22	0.1	2.4	24.5
July 1, 1970 - 3/31/99 Hanford MTU Subtotal							0	0	0	0
Hanford In-Scope MTU Grand Total							22	0.1	2.4	24.5

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Table 3-3 Hanford Receipts From Fernald

TOTAL URANIUM RECEIVED (IN MTUs)							NLO, FMPC, FEMP Fernald Ohio Managed by Oak Ridge Operations EVA, FVB, FVC			
FY	Date		Into RIS	Hanford Contractor	Box #	Doc #	MTU			Hanford MTU Total
	From	To					DU	NU	EU	
1952	01-Jan-52	30-Jun-52	HGE	General Electric	38213	FTS 953	0	0	0	0
1953	01-Jul-52	30-Jun-53	HGE	General Electric	38213	FTS 1085	0	0	0.8	0.8
1954	01-Jul-53	30-Jun-54	HGE	General Electric	38213	FTS 1311	0.1	2,735	0	2,735.1
1955	01-Jul-54	30-Jun-55	HGE	General Electric	38213	FTS 1481	0	4,550	0	4,550.4
1956	01-Jul-55	30-Jun-56	HGE	General Electric	38213	FTS 1644	55.6	4,564	12.3	4,631.7
1957	01-Jul-56	30-Jun-57	HGE	General Electric	38213	FTS 1980	46.5	5,785	62.3	5,893.4
1958	01-Jul-57	30-Jun-58	HGE	General Electric	38213	FTS CLVI 463-1A	9.9	6,841	405	7,255.9
1959	01-Jul-58	30-Jun-59	HGE	General Electric	38213	HAN 72720	0.4	4,699	614.9	5,314.4
1960	01-Jul-59	30-Jun-60	HGE	General Electric	38213	HAN 75996	0	6,352	794.2	7,146.6
1961	01-Jul-60	30-Jun-61	HGE	General Electric	38213	HAN 79125	1.3	5,306	1,308.4	6,615.2
1962	01-Jul-61	30-Jun-62	HGE	General Electric	38213	HAN 82406	0.4	4,956	1,405.6	6,361.7
1963	01-Jul-62	30-Jun-63	HGE	General Electric	38213	HAN 85615	0	5,743	1,760.6	7,504
1964	01-Jul-63	30-Jun-64	HGE	General Electric	38213	HAN 88957	29.4	4,775	1,923.2	6,727.7
1965	01-Jul-64	30-Jun-65	HZA	General Electric	38213	HAN 92119	0	5,580	2,523	8,103.5
FY 1953 - FY 1965 Subtotal							143.7	61,886.8	10,810.2	72,840.7
1966	1-Jul-65	30-Jun-66	HZA	General Electric	38213	HAN 95170	0	1,126.5	1,202.2	2,328.7
1966	1-Jul-65	30-Jun-66	HWA	Isochem Inc.	38213	HAN 95136	0	0	0.3	0.3
Hanford Chem Processing Contractor subtotals							0	1,126.5	1,202.6	2,329.1
1966	1-Jul-65	30-Jun-66	HXA	Douglas United Nuc	38214	HAN 95171	0	1,992.8	1,282.8	3,275.6
Hanford FY 66 Aggregate subtotal							0	3,119.3	2,485.4	5,604.7
1967	1-Jul-66	31-Dec-66	HZA	General Electric	39213	HAN 96413	0	2.1	303.9	305.9
1967	1-Jan-67	30-Jun-67	HZA	General Electric	39213	HAN 98198	0	0.5	186.1	186.5
1967	1-Jul-66	31-Dec-67	HWA	Isochem Inc.	38213	HAN 96400	0	0	0.2	0.2
1967	1-Jan-67	30-Jun-67	HWA	Isochem Inc.	38213	HAN 98196	0	0	0.3	0.3
Hanford Chem Processing Contractor subtotals							0	2.5	490.5	493
1967	1-Jul-66	31-Dec-66	HXA	Douglas United Nuc	38214	DUN 1916	89.6	1,502.7	321.7	1,914
1967	1-Jan-67	30-Jun-67	HXA	Douglas United Nuc	38214	HAN 98194	4.7	1,694.9	950.7	2,650.3
Hanford FY 67 Aggregate subtotal							94.3	3,200.1	1,762.9	5,057.3
1968	1-Jul-67	31-Dec-67	HVA	Atlantic Richfield Han	46425	HAN 99439	0	0.2	0.2	0.4
1968	1-Jan-68	30-Jun-68	HVA	Atlantic Richfield Han	46425	ARH 699	0	0	0.4	0.4
Hanford Chem Processing Contractor subtotals							0	0.2	0.6	0.8
1968	1-Jul-67	31-Dec-67	HXA	Douglas United Nuc	38214	DUN 3624	0	956.7	934.7	1,891.4
1968	1-Jan-68	30-Jun-68	HXA	Douglas United Nuc	38214	DUN 4436	0	296	1,233.5	1,529.6
Hanford FY 68 Aggregate subtotal							0	1,253	2,168.8	3,421.8
1969	1-Jul-68	31-Dec-68	HVA	Atlantic Richfield Han	46425	ARH 1036	0	0	0.1	0.1
1969	1-Jan-69	30-Jun-69	HVA	Atlantic Richfield Han	46425	ARH 1099-6	0	0	0.2	0.2
Hanford Chem Processing Contractor subtotals							0	0	0.4	0.4
1969	1-Jul-68	31-Dec-68	HXA	Douglas United Nuc	38214	DUN 5250	0	75.3	1,320.4	1,395.8
1969	1-Jan-69	30-Jun-69	HXA	Douglas United Nuc	38214	DUN 5942	0	63.3	1,122.5	1,185.8
Hanford FY 69 Aggregate subtotal							0	138.6	2,443.3	2,581.9
1970	1-Jul-69	31-Dec-69	HVA	Atlantic Richfield Han	46425	ARH 1099-12	0.1	0.2	0.3	0.5
1970	1-Jan-70	30-Jun-70	HVA	Atlantic Richfield Han	46425	ARH 1540-6	0	0	0.1	0.1
Hanford Chem Processing Contractor subtotals							0	0	0	0
1970	1-Jul-69	31-Dec-69	HXA	Douglas United Nuc	38214	DUN 6557	0	1,074.3	345.4	1,419.8
1970	1-Jan-70	30-Jun-70	HXA	Douglas United Nuc	38214	DUN 7049	0	707.8	316.3	1,024.1
Hanford FY 70 Aggregate subtotal							0	1,782.1	661.8	2,443.9
FY 1966 - FY 1970 Subtotal							94	9,493	9,522	19,110
FY 1971-3/1999 Receipts into Atlantic Richfield (HVA)							2.33	0	0.04	2.4
10/77-7/87 Receipts into Rockwell (HRA)							0	0.03	6.65	6.7
FY 1971-3/1999 Receipts into United Nuclear (HXA)							0.1	398.6	360.3	759
8/87-3/1999 Receipts into Westinghouse (HUD) & Fluor (HTA)							0	0.44	0.61	1.1
1/1/65-3/1999 Receipts into PNNL (HYA)							4.21	0.04	0.37	4.6
FY 71 thru March 31, 1999 Subtotal							6.6	399.1	368	773.7
Grand MTU Total FY 52 thru March 1999							244.6	71,778.	20,700.3	92,723.9
Grand MTU In-Scope Total FY 52-3/31/99							244.6	71,778.	20,700.3	92,723.9

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Table 3-4 Hanford Receipts From Oak Ridge (K-25 & Y-12)

TOTAL URANIUM (IN MTUs)				K-25 GDP & Y-12						
				Oak Ridge, Tenn						
				Managed by Oak Ridge Operations						
				CCC, CYT, FZE, FZA, FZB, FZF						
FY	Date		Into	Hanford	Box #	Doc #	DU	NU	EU	Hanford
	From	To	RIS	Contractor						MTU Total
1951	1-Jan-48	31-Dec-49	HGE	General Electric	38213	FTS 845	0.2	0	0	0.2
1952	31-Dec-49	30-Jun-52	HGE	General Electric	38213	FTS 953	0.02	0.004	0.40	0.42
1953	01-Jul-52	30-Jun-53	HGE	General Electric	38213	FTS 1085	0	0	0.6	0.6
1954	01-Jul-53	30-Jun-54	HGE	General Electric	38213	FTS 1311	0	0	2.1	2.1
1955	01-Jul-54	30-Jun-55	HGE	General Electric	38213	FTS 1481	0	0	0.4	0.4
1956	01-Jul-55	30-Jun-56	HGE	General Electric	38213	FTS 1644	0	0	0	0
1957	01-Jul-56	30-Jun-57	HGE	General Electric	38213	FTS 1980	0	0	0	0
1958	01-Jul-57	30-Jun-58	HGE	General Electric	38213	FTS CLVI 463-1A	0	0	0	0
1959	01-Jul-58	30-Jun-59	HGE	General Electric	38213	HAN 72720	0.1	0	0.1	0.1
1960	01-Jul-59	30-Jun-60	HGE	General Electric	38213	HAN 75996	0	0	0.4	0.4
1961	01-Jul-60	30-Jun-61	HGE	General Electric	38213	HAN 79125	0	0	0.4	0.5
1962	01-Jul-61	30-Jun-62	HGE	General Electric	38213	HAN 82406	0	0	0	0.1
1963	01-Jul-62	30-Jun-63	HGE	General Electric	38213	HAN 85615	0.1	0	0	0.1
1964	01-Jul-63	30-Jun-64	HGE	General Electric	38213	HAN 88957	0	0	0	0
1965	01-Jul-64	30-Jun-65	HZA	General Electric	38213	HAN 92119	0	0	0	0
FY 1953 - FY 1965 Subtotal							0.4	0.1	4.4	4.9
1966	1-Jul-65	30-Jun-66	HZA	General Electric	38213	HAN 95170				0
1966	1-Jul-65	30-Jun-66	HWA	Isochem Inc.	38213	HAN 95136				0
Hanford Chem Processing Contractor subtotals										
1966	1-Jul-65	30-Jun-66	HXA	Douglas United Nuc	38214	HAN 95171				0
Hanford FY 66 Aggregate subtotal							0	0	0	0
1967	1-Jul-66	31-Dec-66	HZA	General Electric	39213	HAN 96413				0
1967	1-Jan-67	30-Jun-67	HZA	General Electric	39213	HAN 98198				0
1967	1-Jul-66	31-Dec-67	HWA	Isochem Inc.	38213	HAN 96400				0
1967	1-Jan-67	30-Jun-67	HWA	Isochem Inc.	38213	HAN 98196				0
Hanford Chem Processing Contractor subtotals										
1967	1-Jul-66	31-Dec-66	HXA	Douglas United Nuc	38214	DUN 1916				0
1967	1-Jan-67	30-Jun-67	HXA	Douglas United Nuc	38214	HAN 98194		0.034		0
Hanford FY 67 Aggregate subtotal							0	0.034	0	0
1968	1-Jul-67	31-Dec-67	HVA	Atlantic Richfield Han	46425	HAN 99439				0
1968	1-Jan-68	30-Jun-68	HVA	Atlantic Richfield Han	46425	ARH 699				0
Hanford Chem Processing Contractor subtotals										
1968	1-Jul-67	31-Dec-67	HXA	Douglas United Nuc	38214	DUN 3624			0	0
1968	1-Jan-68	30-Jun-68	HXA	Douglas United Nuc	38214	DUN 4436				0
Hanford FY 68 Aggregate subtotal							0	0	0	0
1969	1-Jul-68	31-Dec-68	HVA	Atlantic Richfield Han	46425	ARH 1036				0
1969	1-Jan-69	30-Jun-69	HVA	Atlantic Richfield Han	46425	ARH 1099-6				0
Hanford Chem Processing Contractor subtotals										
1969	1-Jul-68	31-Dec-68	HXA	Douglas United Nuc	38214	DUN 5250		0.05		0.1
1969	1-Jan-69	30-Jun-69	HXA	Douglas United Nuc	38214	DUN 5942				0
							0	0.05	0	0.1
1970	1-Jul-69	31-Dec-69	HVA	Atlantic Richfield Han	46425	ARH 1099-12				0
1970	1-Jan-70	30-Jun-70	HVA	Atlantic Richfield Han	46425	ARH 1540-6				0
Hanford Chem Processing Contractor subtotals										
1970	1-Jul-69	31-Dec-69	HXA	Douglas United Nuc	38214	DUN 6557				0
1970	1-Jan-70	30-Jun-70	HXA	Douglas United Nuc	38214	DUN 7049				0
Hanford FY 70 Aggregate subtotal							0	0	0	0
FY 1966 - FY 1970 Subtotal							0	0.084	0	0.084
FY 1971 -3/1999 Receipts into Atlantic Richfield (HVA)							0	0	0	0
10/77-7/87 Receipts into Rockwell (HRA)							0	0	0	0
FY 1971 -3/1999 Receipts into United Nuclear (HXA)							0.9	0	0	0.9
8/87-3/1999 Receipts into Westinghouse (HUD) & Fluor (HTA)							0	0	0	0
1/1/65-3/1999 Receipts into PNNL (HYA)							12.6	0.2	0.8	13.4
FY 71 thru March 31, 1999 Subtotal							13.6	0	0.8	14.3
Grand MTU Total 1947 thru March 1999							14	0.2	5.2	19.4
MTU In-Scope Total FY 1953 thru March 1999							13.8	0.2	4.8	18.7